Emittance grown by gas in hybrid channel (preliminary)

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Overview

- Estimate heating of muon beam due to interaction with buffer gas in a hybrid channel
  - Buffer gas consists either pure gaseous hydrogen or SF6 doped GH2
- For simplicity, I assume no energy loss process
  - Momentum is constant in a channel

Heating model

- Conventional equilibrium emittance formula

$$\varepsilon_{t,n} \propto \frac{\bar{\beta}_t}{X}$$

$\bar{\beta}_t$: Average transverse beta function

- Formula for a radiation length

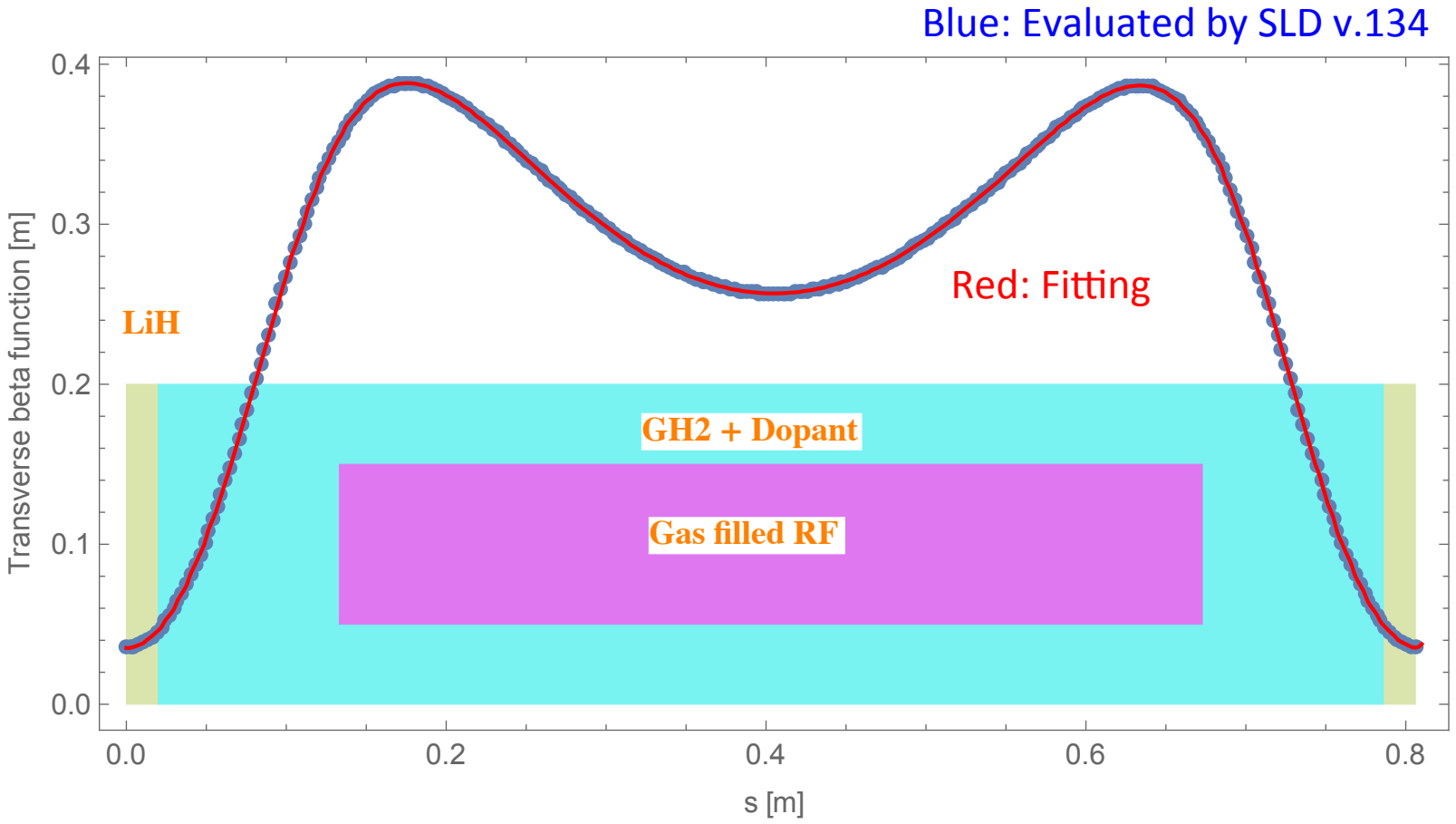
$$\frac{1}{X} = \sum_i \frac{w_i}{X_i}$$

w_i: Statistic weight

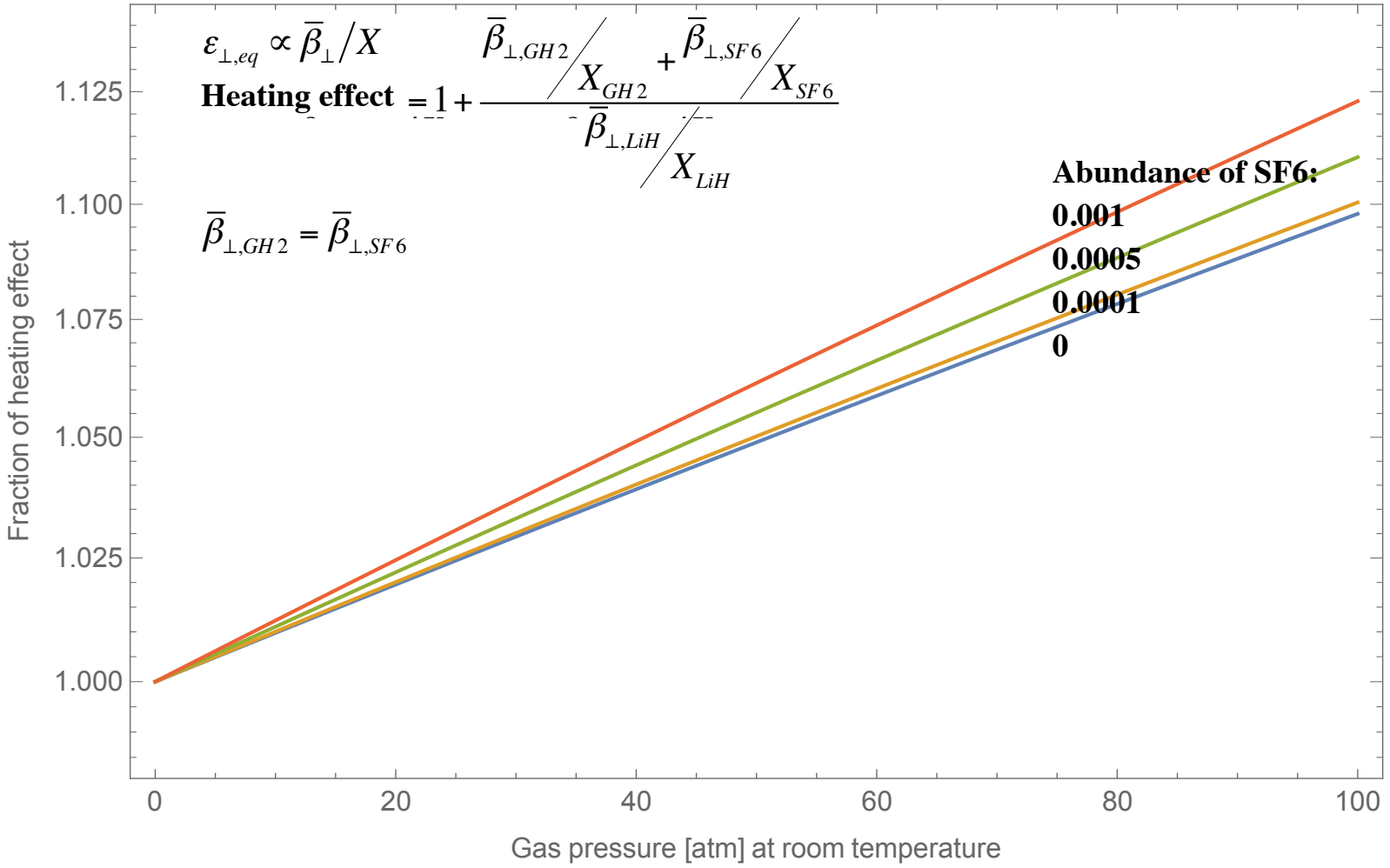
where I used
ρ_{H2} = 8.89e-5 g/cm3, X_{H2} = 63.04 cm2/g
ρ_S = 1.43e-3 g/cm3, X_S = 19.50 cm2/g
ρ_F = 1.58e-3 g/cm3, X_F = 32.93 cm2/g
ρ_{LiH} = 0.82 g/cm3, X_{LiH} = 79.62 cm2/g

from PDG

Transverse beta function in a rectilinear channel

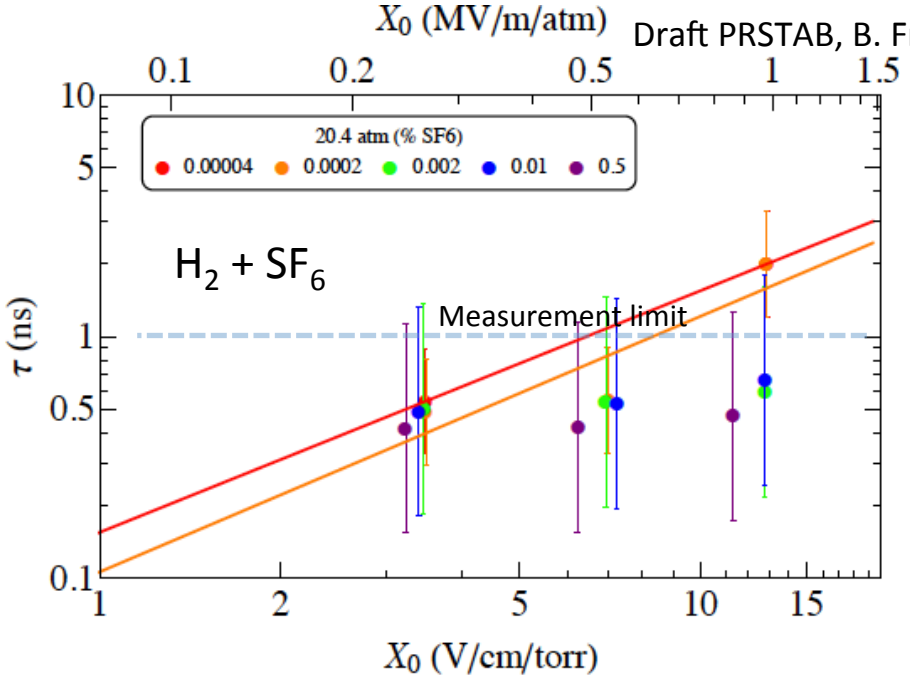


Estimate heating effect



Electron capture in SF6

Observed electron capture constant in HPRF test



Draft PRSTAB, B. Freemire

0.0002 of SF6 is sufficient to capture ionization electrons in 1 ns
-> Plasma loading is manageable

0.0002 of SF6 in 100 atm GH2 will heat the muon beam by only 10 % (see the plot in previous slide)

X_0 ~ 4 V/cm/torr for E = 30 MV/m in P = 100 atm

Discussion

- Emittance grown by buffer gas is small
  - 80 ~ 100 atm looks acceptable
  - A small fraction of SF6 dopant significantly reduces the plasma loading effect
  - Heating by a buffer gas will be comparable with the heating by Be RF windows
    - I need to know the exact location of windows and their geometries to estimate the window effect
- Need to re-evaluate cooling simulation
  - Energy loss along the beam path will make lower beta function, i.e. gas may provide lower equilibrium emittance